enerSave
For Municipalities

Saving Energy in Municipal Buildings

Energy, Mines and Resources Canada | Énergie, Mines et Ressources Canada

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Saving Energy in Municipal Buildings

Introduction

Buildings account for a larger portion of a municipality's total energy consumption than any other item in the energy budget. In a survey of energy use in seven Canadian municipalities,* energy use in buildings was never less than 33% of the total. When transit figures are excluded, this proportion rises to approximately 50%.

Table 1 illustrates the relative weight of buildings in the overall municipal energy picture.

Because of the complexity of their operation, municipal buildings also offer sizable energy savings, often for little or no cost. Apart from the building shell, heating, air ventilation and air conditioning systems, service hot water and various building operations are all good targets for conservation efforts.

TABLE 1

ENERGY USE IN MUNICIPAL BUILDINGS

	Total Energy Consumption (GJ)	Bldg. Floor Area (M^2)	Total Bldg. Energy (GJ)	Bldg. as % of Total	Bldgs. as % of total less transit
Montague, PEI (pop. 1,800)	3,508	706	1,547	44	44
Summerside, PEI (pop. 8,600)	32,650	8,089	18,163	56	56
Granby, Quebec (pop. 37,300)	138,369	27,554	51,851	37	52
Victoria, B.C. (pop. 63,800)	257,929	102,672	92,914	36	53
Saint John, N.B. (pop. 35,900)	293,935	69,312	122,849	42	48
Ottawa, Ont. (pop. 304,500)	1,360,325	264,032	462,956	34	51
Winnipeg, Man. (pop. 560,900)	1,945,108	372,631	721,980	37	53

*Source: Municipal Energy Audit: A Practical Guide to the Identification of Energy Expenditures, Building Series No. 3, Department of Energy, Mines and Resources.

These efforts, however, can be complicated by the variety of building types occupied and operated by local governments. These may include

- office buildings
- various kinds of garages and vehicle depots
- repair and maintenance shops
- community centres and libraries
- fire and police stations
- arenas, swimming pools and other sports facilities
- municipal baths
- sewage and water treatment plants, pumping stations, etc.
- city-owned apartment buildings and houses

For some of these categories (e.g. office buildings) conservation techniques are well researched, and extensive and specific literature already exists. Less is known about conservation in other types of municipal buildings, such as sports facilities, and these may therefore present problems in an energy conservation program.

1- A Strategy for Conservation in Buildings

A comprehensive campaign based on no-cost and low-cost conservation measures offers the best initial strategy for reducing energy waste in municipal buildings. This in-house optimization of a building's energy performance should be carried out by the city's staff (possibly with assistance of a mechanical and/or electrical consulting engineer). Changes to operating and maintenance procedures would be particularly important at this stage. Once in-house measures are introduced, a professional analysis should then be carried out by a qualified consulting engineering firm.

The in-house buildings program is an obvious and potentially effective part of a municipality's conservation strategy. Savings from operation and maintenance measures can range from 10 to 40%. In addition the pay-back period for investments seldom extends beyond one full season of operation.

The importance of hiring a professional energy consultant may appear less obvious, but failure to do so can lead to oversights. These unrecognized opportunities for energy savings, and delayed decisions, may cost taxpayers many times more than the consultant's fee. Ideally this consultant should work closely with municipal maintenance staff, involving them in the introduction of new conservation measures and in monitoring the effects of the program.

Operating Guidelines for Energy Conservation, a Public Works Canada publication, is attached as an Appendix. A comprehensive and detailed manual, it provides a sound basis for in-house conservation activities in buildings of any size.

2- A Breakdown of Energy Use in Buildings

By far the largest amount of energy consumed in buildings (for non-process purposes) is in heating, usually in the form of oil or gas, less often in the form of electricity. In offices or apartment buildings heating energy often exceeds 50% of the building's total consumption, rising to more than 90% in garages. Typically, much of this energy, often more than half, can be saved by cost-effective modifications to heating and ventilation systems, to the building's shell, and through improved operation and maintenance of equipment.

Lighting, the second largest energy consumer in most buildings, may account for more than 30% of total energy use. It also offers one of the greatest opportunities for savings, as North American buildings constructed over the past 20 to 30 years were routinely overlighted.

Air handling and water pumping equipment (i.e. fan and pump motors) also consume significant amounts of energy, anywhere from 8 to 25%. Much of this energy can be saved by turning off fans and pumps when they are not needed (the least expensive option), by slowing down belt-driven fans to the minimum acceptable speed (again a low-cost measure) and finally by replacing oversized or inefficient motors with better matched, higher efficiency, or variable speed motors. The last measure is expensive and usually not justified economically unless motor replacement is necessary for other reasons.

Mechanical cooling of conventional buildings equipped with traditional air conditioning systems is next in significance, and on an annual basis may account for 10% of total energy consumption. From the perspective of

cost, the cooling load accounts for even a larger share: typically electrical, it is usually required at the same time as the rest of the electrical load, thus increasing demand charges. (See "Electricity - Consumption and Demand").

3- Introducing Conservation Measures

As noted earlier, major energy savings can be achieved in buildings by changes in operation and maintenance routines, and by retrofit of the building's shell and its energy systems.

Operations and maintenance measures are generally low cost, requiring little or no capital investment. At the same time, they may account for a very significant drop in energy use. For this reason they should be implemented as soon as they are identified.

On the other hand, retrofit of the building shell and energy systems requires capital expenditures. Often significant, these costs should be carefully analyzed and such projects assigned a priority in the context of the overall conservation program. Some projects may appear very attractive when viewed in isolation, yet become uneconomical when re-evaluated because other conservation options offer the same potential benefits for lower costs.

For this reason it is advisable to employ qualified and experienced engineers to conduct a thorough cost-benefit analysis of the technical options. A consultant can also be useful in monitoring implementation of conservation activities to ensure that the program is as immediate and cost-effective as possible. Where consultants are employed, however, it is important to make sure they have the background required to evaluate energy conservation opportunities correctly.

Heating and cooling systems

Heating systems, or heating and cooling systems, are found in nearly all buildings in Canada. Typically these systems also provide ventilation and ensure air movement within the occupied spaces, both necessary for the comfort of occupants. This is why operation of these systems (called HVAC systems) is often required during occupied hours, even when cooling and heating are not needed.

One of the first rules of rational energy management is to turn these systems off as soon as their operation ceases to be necessary. Usually this can be done even before the occupied period ends, and the systems can remain inactive for most or all of the time the building is unoccupied. Savings from these simple and generally inexpensive measures are significant, although the amount of energy conserved depends to some degree on the type of HVAC design.

Optimization and adjustment of controls suggest another set of useful measures which are applicable to most buildings. A capacity for flexible but accurate temperature control in occupied spaces, particularly the ability to reset temperature control according to the season and the time of day (i.e. night setback), can produce very significant reductions in energy use.

Some HVAC systems, however, are inherently inefficient even if properly operated and maintained.

Among these are such remnants of the pre-1973 era as the "terminal reheat" system or certain variations of the "dual duct" system. Both these general categories of mechanical systems have one common feature: most of the time the same air must be both heated <u>and</u> cooled before it is discharged into the conditioned space.

This duplication, and the associated energy waste, are the price designers used to pay for the extraordinary flexibility of operation and the precision of control such systems offer. These systems became extremely popular in the 1960's and early 1970's, during the construction boom, and are perhaps most commonly found in the more modern buildings.

Buildings designed today are outfitted with far more efficient HVAC systems. These eliminate simultaneous heating and cooling, and are often equipped with a "variable volume" feature that automatically regulates the volume of cool air brought into building spaces to match the cooling and heating demand. In this way operating costs and heating and cooling requirements are reduced. It is now possible to design a large office building where all heating requirements are supplied by heat from people, lights and equipment.

It may be possible for municipalities to convert some of the older, routinely "constant volume" systems into "variable air volume" (or VAV). In most cases, because radical conversion would be uneconomical, a building will have to retain its existing HVAC system. Other modifications for improving an existing system's efficiency may still be practical, however, and these should be identified in an energy audit. For example:

- Supply air temperature on a constant volume or dual-duct system can be controlled on a variable basis rather than at a pre-set constant temperature.

- Primary supply air temperature in an induction HVAC system may be adjusted to avoid simultaneous heating and cooling.

- Air flows can be checked and rebalanced as required.

In any building, the occupants, equipment and lighting generate heat. This heat can provide part or all of a building's heating needs, if captured, stored and redirected. The heat pump is one of the most common systems for recovering and redirecting otherwise wasted heat of this kind. Sophisticated systems have been designed using internal source heat pumps in large office buildings. These are particularly feasible when there is a uniform and continuous heat source, such as a large computer installation.

While heat pumps and other heat recovery systems (such as heat wheels and runaround coils) may not be economically feasible today for most existing buildings, their potential application should nevertheless be evaluated.

Lighting

Lighting is among the largest energy users in commercial buildings, both in energy used directly for illumination and in the increased cooling demand caused by the heating effect of lights. On average, for the entire year, every watt of energy for lighting requires more than another one-half watt of energy for cooling, pumps and fans.

Over the years, lighting levels in North America have steadily increased, until now they are twice as high as in many European countries. There is no necessity for such high lighting levels in most buildings. Furthermore, high lighting levels are not synonymous with high quality illumination. The growing need to conserve energy suggests that it is time to concentrate on lighting quality rather than quantity.

Many existing office buildings are equipped with recessed fluorescent fixtures providing an average of 100 foot-candles illumination. These buildings use an average of 42 watts of lighting per square metre (4 watts per square foot). In contrast, new buildings are designed either with coffered ceilings or task lighting. As a result they consume less than 20 watts per square metre and provide working areas with 70 foot-candles illumination.

This more efficient lighting design also reduces cooling, pumping and fan loads. Together with the direct savings from reduced lighting, this translates into an impressive savings of at least 20% of a building's total energy consumption.

While savings are not attainable to the same effect in most existing buildings, lighting loads can be reduced by as much as half by the following measures:

- Disconnect all unnecessary fixtures in the working area.

- Eliminate a portion of lighting fixtures in non-critical areas such as lobbies, corridors and storage rooms. Light in these areas should be as low as safety and security will allow.

- Reduce lighting near windows. Separate circuits or dimmers are desirable in any areas where full illumination is only periodically necessary.

- When burned tubes are replaced, substitute more efficient types.

- Keep walls, ceilings and fixtures clean, and choose colours that reflect light. Dark colours and dirt reduce illumination.

- Turn off lights when rooms are not in use, and insist that cleaning staff do the same.

Water heaters and other energy loads

Domestic hot water is not among the largest consumers of energy in a commercial building, but significant savings are possible by reducing the water temperature

to 40°C or less, insulating tanks and pipes where accessible, and installing automatic valves or flow reducing devices.

Building envelope

The amount of energy necessary to heat buildings is essentially determined by the quality of the building enclosure and more specifically by its thermal resistance and air tightness.

The thermal resistance of the building enclosure is a function of the insulating properties of walls, roofs, and windows. Improvements to this thermal resistance are often expensive, and a thorough economic analysis may be necessary to justify reinsulation of walls, retrofit of windows, or improvements to the roof. On the other hand, sealing the building's envelope to reduce uncontrolled infiltration of outside air may be more straightforward and cost-effective if the major causes of infiltration can be determined. Many traditional and new materials are available to improve air tightness of buildings, including caulking compounds.

Thermal retrofit of buildings should always be considered when renovations or modifications are contemplated: insulation of a roof may be done for little more then the cost of insulation material if installed at the time of re-roofing, whereas it will be a much costlier investment at other times.

Ventilation

Most modern buildings rely on mechanical ventilation to provide occupants with a clean and odor-free environment. Standards and established procedures govern the design and operation of ventilation systems to ensure that this job is done adequately. Experience with hundreds of existing Canadian buildings, however, indicates that in the majority of cases ventilation systems are designed and operated in such a manner that extravagant amounts of heating and cooling energy are wasted in the process. Optimization of ventilation is among the most cost effective measures available to the building owner.

It is now generally accepted that in most buildings 7 to 10 cfm (3 to 5 L/s) of fresh air per occupant is sufficient to maintain satisfactory conditions. Actual practice, however, may exceed this minimum many times.

Ventilation can be reduced in various ways: by adjusting the outside air damper of the central system to the minimum setting, by repairing or replacing leaky dampers, by reducing the "on" time of HVAC systems and exhaust fans, and so on.

It is impossible to give a simple and general formula for determining the amount of "new" energy needed to heat ventilation air throughout the heating season, as this depends on the characteristics of the building. It can be safely said, however, that excessive mechanical ventilation, combined with uncontrolled infiltration, costs building owners millions of dollars each year.

Electricity-consumption and demand

Electricity is the most convenient form of energy for use in buildings. In spite of its generally higher cost, some buildings rely on electrical power to meet all their energy needs, including heating.

Most of the energy conservation measures discussed here apply equally to all-electric buildings as well as to those heated by fuels. Electricity, however, differs from other fuels in the way the supplier, in this case the utilities, charges for it.

Two basic charges appear on electricity bills: the consumption charge and the demand charge. Consumption charge is essentially straightforward, although rates usually decrease (in blocks) as consumption increases. For example, the first 10,000 kwh consumed within one billing period (a month) may cost $332.00, while the balance may be charged at $0.0216/kwh.

Demand charges depend on the highest instantaneous flow of electric current recorded in the given billing period, and are expressed in $/kw. Demand meters normally do not register short duration surges, but any peak load lasting fifteen minutes or more will be fully recorded.

Demand charges may be structured in many different ways. The most typical are single rates per kw, or single rates above the

initial, free of charge, block (i.e. first 50 kw - no charge, with the balance charged at $6.00 per kw). Some utilities also employ a "rachet clause", which usually means a full year "penalty" for a single peak in demand.

The rate structure is a very important factor in conservation strategy. Two identical buildings, initially paying equal amounts for their electricity, located across the street from one another, belonging to the same owner, operated by the same crew, and audited by the same engineer, may adopt different conservation measures if fed with electric power from different utility companies.

One rate may favour off-peak utilization of power through high demand and low consumption charges, leading the building owner to install a thermal storage tank for both hot and chilled water, combined with night operation of chillers and/or electric resistance heaters, and a drastic regime of load shedding, especially if the rachet clause applies.

The other rate may favour reduction of consumption without significantly reducing the peak demand through a higher consumption rate but lower demand charges. This may justify more radical lighting level reduction, but neither thermal storage nor load shedding.

There are many sources of information on the subject of utility rates and how they affect energy conservation strategies. However a thorough analysis by a qualified engineer will result in appropriate recommendations These will be based on local rates, bills for at least one full season, demand picture (some utilities will install a demand recorder in your building free of charge for a limited period of time) and energy systems (e.g. HVAC, lighting, hot water).

With the exception of non-inductive loads (e.g. resistance heaters or incandescent lamps) almost all electrical equipment tends to distort or degenerate the electric current. One measure of this degeneration is the Power Factor (P.F.), a function of the angle of lag of the current (amps) behind the tension (volts). Power Factor is excellent if it equals 1.0 (its maximum possible value), good if larger than 0.9, and usually unacceptable when it falls below 0.85. Certain utilities penalize their clients for low P.F. The P.F. can be corrected by installing capacitors of an appropriate size and type.

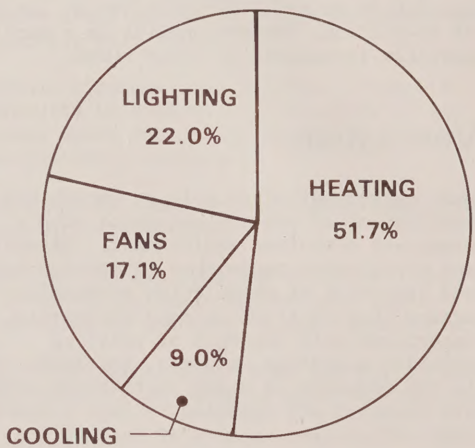
4- Analysis of Building Energy Systems

There is no substitute for professional cost benefit analysis of a building's energy systems. This analysis can be done through a professional evaluation with the application of simplified "manual" calculations, although in more complex cases a computer simulation offers advantages worth considering.

Computer simulation of building energy systems is a relatively new and useful tool in the hands of the engineer. It allows far more accurate calculations of energy balance, and lends itself to easy evaluation of alternatives.

An analysis of a typical office building, performed by Vinto/Yoneda for the National Research Council, illustrates the kind of information produced by a computer simulation.

- The building analyzed, a 130,000 ft^2 office tower located in Edmonton, consumed 2.45 $GJ/M^2/yr$ (63.2 $kwh/ft^2/yr$) of energy, broken down as illustrated:



The engineers identified the following 12 conservation measures which should be

considered by an office building owner in any rational energy conservation program:

- reduction of outdoor air intake
- shutdown schedule
- unoccupied temperature reset
- humidification and dehumidification (revised settings)
- revisions to lighting levels (i.e. shut off during unoccupied periods, general reduction of lighting levels, replacement of some lamps by "phantom tubes" or similar devices)
- ambient reset of supply air temperature
- demand reset of supply air temperature
- domestic hot water temperature reduction
- cooling with outdoor air
- air flow rate reduction
- lower condenser water temperature

First, the following four specific measures were evaluated:

1. Shutdown of building mechanical and electrical systems from 6:00 p.m. to 7:00 a.m. weekdays and all day on weekends.

2. Seasonal thermostat settings of 70°F degrees from October 1 to May 31, and 76°F degrees from June 1 to September 30.

3. Removal of tubes from light fixtures to reduce lighting energy to 2.5 watts per square foot.

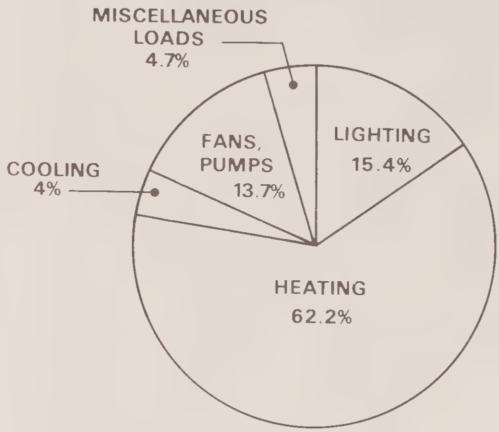
4. Reset of domestic hot water temperature to 110°F from 140°F.

The computer-simulated implementation of all the above items in the base model decreased the annual equivalent energy consumption by 50%. Large reductions in heating and cooling requirements were realized. A small reduction in the domestic hot water resulted. The lighting energy requirement was also reduced significantly. The most dramatic energy requirement reduction was related to fan energy with a saving of almost 80%. The consumption of electrical accessories was reduced by 23%. Overall building electric consumption was reduced by 48%, and the electrical demand peak was reduced by 21%. Gas consumption was reduced by 53%.

The energy saving increased to more than 60% by implementing all items, including those requiring expenditures.

Another example of a computer analysis of an existing building was carried out for the Atmospheric Environment Service in Toronto:

o This analysis dealt with a 320,000 ft^2 office building consuming 79 $kwh/ft^2/yr$.



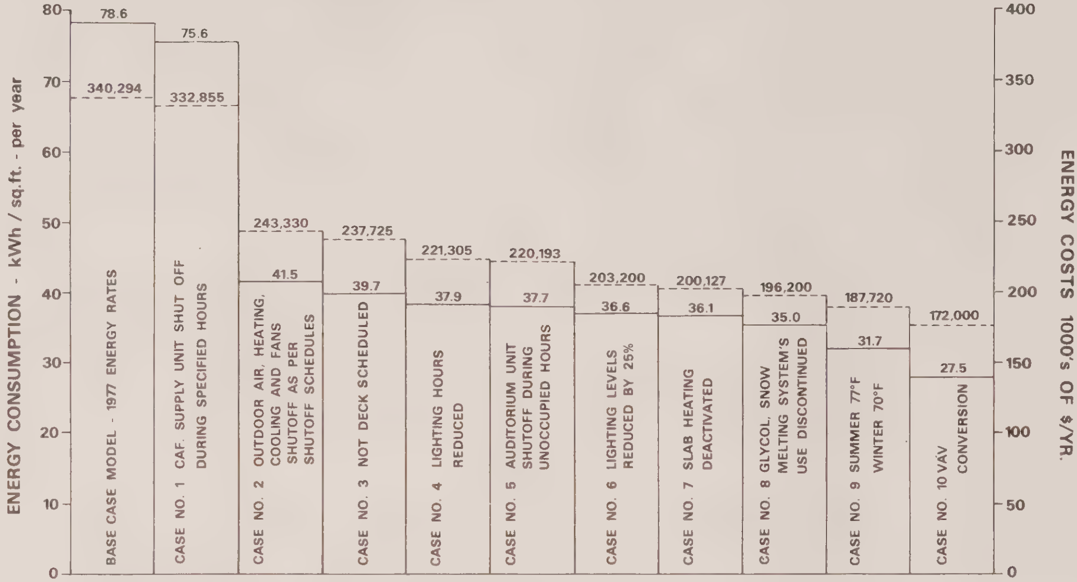
The cost benefit analysis, done by Public Works Canada and aided by use of the computer simulation, led to the "cascade" of conservation options as illustrated in Figure 1. (The full report is available from Public Works Canada, Headquarters, Sir Charles Tupper Building, Riverside Drive, Ottawa K1A 0M2)

These two examples demonstrate the quality of information available through an in-depth energy analysis of a building performed with the aid of a computer program. This approach enables the engineer to accurately identify the intricate dependence on the local weather of energy consumption in buildings. It also takes into account the interdependence of the energy systems and the building's physical properties.

Only the larger and more complex buildings could warrant the cost of the computer analysis, however. For simpler cases less expensive calculations, supported by knowledge and experience, may be sufficient. On the other hand simplified and less expensive computer programs, often based on mini-computers, are now being developed. These bring the cost of computer analysis down to more affordable levels.

FIGURE 1

ENERGY PERFORMANCE CASCADE FOR THE ATMOSPHERIC ENVIRONMENT SERVICE BUILDING IN TORONTO



Source: Energy Conservation Study, Atmospheric Environment Service Building, Public Works Canada, Technological Research and Development, Technical Note Series, June 1977.

5- Review of Selected Publications

There is a large number of publications dealing with energy conservation in buildings. Six volumes of bibliographies on conservation have been published by the Department of Energy, Mines and Resources, one on each of the following six building categories:

Schools	Building Series No 2a
Retail stores	Building Series No 2b
Multiple Dwellings	Building Series No 2c
Hospitals	Building Series No 2d
Hotels and Motels	Building Series No 2e
Office Buildings	Building Series No 2f

Listed and reviewed in these publications are manuals, research reports and articles. These bibliographies are available from:

Conservation & Renewable Energy Branch
Department of Energy, Mines and Resources
580 Booth Street
Ottawa, Ontario
K1A 0E4
(Attention Buildings Division)

The following publications were chosen for review here because they are particularly relevant as reference books for energy conservation in municipal buildings:

How to save Energy and Cut Costs in Existing Industrial and Commercial Buildings: An Energy Conservation Manual

Dubin, Mindel, Bloome. Published by Noyes Data Corporation, Park Ridge, N.J., U.S.A., 1976

One of the most comprehensive manuals on energy conservation, this document consists of more than 700 pages, with more than 100 diagrams. It is divided into two parts, "Building Owners and Operators Manual", and

"Engineers, Architects, and Operators Manual". Both sections deal essentially with the same topics, treated somewhat differently to satisfy the needs of the audiences specified in the titles.

The manual examines the question of how to establish an energy management program, and then proceeds to review individual conservation opportunities in heating and air conditioning, domestic hot water, cooling and ventilation, commercial refrigeration, distribution and HVAC systems, heat reclamation, lighting, power, central systems, alternative energy sources, economic analysis, computer programs, and so on. Several appendices review codes and standards, cost data, and examples.

The treatment of conservation opportunities is generally brief, but graphs and formulae are very useful for assessing and quantifying energy used and saved. Graphs from this manual are widely quoted in various other publications on conservation.

This manual can be recommended as the basic source of conservation engineering data for both technical and non-technical audiences.

Measures for Energy Conservation in New Buildings, 1978
Issued by the Associate Committee on the National Building Code, NRC, Ottawa. Available from National Research Council, Montreal Road, Ottawa, Ontario, K1A OR6. Cost $2.00

Intended as a companion document to the National Building Code, this publication prescribes building design requirements for architects and engineers. At the time of writing, these Measures have not yet been adopted by any of the provincial legislatures. Most provinces, however, are reviewing the document and may adopt the Measures in the original or modified version.

The publication prescribes thermal properties of walls and windows and limits to fenestration (window to wall ratio), attempts to set energy levels for air handling, calls for a minimum of automatic control, recommends temperature ranges and settings, discourages simultaneous heating and cooling (commonly built into the pre-1973 vintage buildings), promotes "free cooling" with "enthalpy control", prescribes pipe and duct insulation, recommends performance coefficients of some refrigeration equipment, heat recovery systems, and domestic hot water equipment, and limits lighting levels.

A prescriptive document, the Measures are largely based on ASHRAE standard 90-75. They intended to impose minimum standards for the design and construction of buildings until the advent of the performance code which will set acceptable limits on annual energy consumption instead of prescribing details of construction or equipment efficiencies.

The Measures, although not yet law, have been voluntarily adopted by many federal, provincial, and other organizations as minumum criteria of acceptable design. It must be recognized, however, that many designers and builders of commercial and residential buildings already exceed the recommendations of the Measures for purely economic or marketing reasons. This suggests that the standards set out in the Measures may now be too low, and that actual design practice may have in many cases surpassed them.

Energy Conservation Design Resource Handbook
Published by the Royal Architectural Institute of Canada, available from RAIC, Suite 1106, 151 Slater Street, Ottawa, Ontario. K1P 9Z9. cost $75.00

Approximately 500 pages long, this book covers the important aspects of energy consumption as affected by the design of buildings. Written mostly for architects and not for energy systems specialists, most parts of the Handbook are accessible to a wider and not necessarily technical audience. Although intended as a design aid, it explains the physical phenomena and principles involved and is therefore a useful general source of information on energy in buildings. On the other hand, its usefulness for conservation programs in existing buildings is limited.

The Handbook includes chapters on climate, energy gain and loss in internal environmental heating and cooling, infiltration, physics of buildings, HVAC systems, lighting, retrofit of existing buildings, urban planning, energy economy, and several other topics.

Energy Conservation in Existing Arenas
(Three Case Studies)

and

Design Guidelines for Energy Conservation
in Skating Rinks and Arenas

Published by the Ontario Ministry of Energy, available from Publication Service, 5th Floor, 880 Bay Street, Toronto, Ontario M7A 1N8

These two books address the problem of energy conservation in uniquely municipal structures which are found in almost all medium-sized and larger municipalities in Canada. Both publications are concisely and clearly written and well illustrated.

APPENDIX

Operating Guidelines for Energy Conservation in Existing Buildings and Heating Plants, Public Works Canada, 1981.

CONTENTS

1- Heating and Cooling Systems

Operating Criteria

Public Works Canada guidelines state that heating and cooling temperatures in PWC administered buildings be maintained in accordance with the following criteria:

Maximum heating temperature:
- working hours, 21°C
- nights, weekends and holidays, 18°C

Minimum cooling temperature:
- working hours, 25°C
- nights, weekends and holidays, 29°C.

To satisfy the above criteria and also realize the maximum energy saving possible in the operation of building heating and cooling systems, system adjustments and other measures described in the following paragraphs should be carried out in all PWC buildings, to the extent practicable. However, each major building represents a unique situation, and the proposals contained herein should be recognized as having general application, only. The application of some of these measures must be considered in the light of specific building systems and their inherent design limitations, the interdependency of individual building systems, and any special client occupancy requirements. In some cases, building operating staffs may have insufficient knowledge of these considerations, and it may be advisable to seek professional advice before certain adjustments are carried out.

General

Weekdays, during the heating season, reduce temperature control settings in the building to maintain a maximum temperature of 21°C between 08:00 and 17:00, and set back the temperature to 18°C between 17:00 and 05:00 weekdays, and during weekends and holidays.

Operation of Building Heating Systems

With the temperature set back to 18°C, when the building is unoccupied, preheat the building, commencing after 05:00 on weekdays, so that it achieves 21°C by approximately 07:00, when occupants begin to arrive at work. Consideration should also be given to commencing the reduction of temperatures to night setback levels at 16:00, on weekdays, where client cooperation can be obtained. (Tests have shown that an approximate 8 to 10 percent saving, in the energy required to heat a building, can be achieved with a 3°C night temperature setback. However, it is inadvisable to lower temperatures more than 3°C, because the system will use progressively more of the energy saved, in bringing the temperature back up to 21°C, for daytime operation.)

Air Systems

Shut off all air systems from 17:00 to 07:00 weekdays and during weekends and holidays that are not needed to maintain the minimum 18°C temperature during the unoccupied periods. The following types of systems should be evaluated for intermittent shut-off:

a) Perimeter Air systems
b) Interior Zone or Core Area systems
c) Multi-duct systems
d) Central and Terminal Reheat systems
e) Other combined systems

Commercial Areas

Maintain commercial areas at a temperature of 20°C during normal business hours, in the heating season, and maintain related non-occupied storage areas at a temperature of 15°C or lower. (Obtain approval of commercial tenant if lease conditions are at variance with the above.)

Garages, Interior Loading Docks, etc.

If feasible, consider shutting off all heating in garages, unoccupied areas, interior loading docks, and platform areas. (Caution must be exercised where there is danger of freezing service water lines or sprinkler lines.)

Building Lobbies, Enclosed Corridors and Vestibules

Consider closing supply registers and radiators, and reducing thermostat settings to 10°C, or turning off electric heaters in building lobbies, enclosed corridors and vestibules during the heating season, where freeze-up of service lines will not occur.

Portable Electric Heaters

Obtain client agreement to ban the use of portable electric heaters by building occupants.

Ramp Snow Melting Systems

Discontinue the use of ramp snow melting systems, except for critical applications, and consider the use of "snow sensors" to control the temperature of the heating media.

Roof Ice Melting Systems

Discontinue the use of roof ice melting systems, except during periods when ice build-up is such that a safety hazard to pedestrians exists.

Storage Rooms

Do not heat unoccupied storerooms or dead storage areas, unless heat is required for the protection of stored contents or service lines.

Humidification Systems

Turn off humidification equipment whenever the building is unoccupied, except when processes or special requirements, such as those associated with art galleries, museums, some laboratory operations, or equipment requirements, etc., take precedence.

Operation of Building Cooling Systems

General

Cool building during the summer months, as necessary, to maintain 25°C between 08:00 and 17:00 weekdays, and set back the temperature to provide cooling only when the temperature reaches 29°C, during the period from 17:00 to 08:00 on weekdays, and during weekends and holidays. Where conditions permit, and client cooperation is obtained, schedule pre-cooling startup in the morning, depending upon outdoor air temperature, so that the building interior temperature will be at 27°C, when building occupants begin to arrive at 07:00. Complete cooling down during the first hour of occupancy to achieve 25°C at approximately 08:00. Consider shutting off all cooling in the building at 16:00, or one hour prior to the end of occupancy each working day. (Special consideration will have to be given to computer rooms where the primary concern is to maintain a constant temperature/humidity relationship. Equipment manufacturers should be consulted to determine permissible ranges of temperature/humidity for their equipment.) During evening and night hours in the cooling season, flush the building with cooler outdoor air to remove heat from the structure, if outdoor humidity is not too excessive.

Operation of Outside Air Dampers

Close outside air dampers for the first and last hour of occupancy whenever makeup air has to be cooled. Caution should be exercised to ensure that only the minimum

amount of outside air is brought into the building on humid days during normal operation.

Infrequently Used Space

Reduce the use of cooling in spaces in the building which are used infrequently, or only for brief periods of time.

Reheat Systems

Turn off reheat in all areas during the summer months, except where operating requirements necessitate humidity control.

Window and Through Wall Air Conditioning Units

Turn on self-contained window and through-wall air conditioning units only when required, and turn them off when the space is to be unoccupied for several hours. However, if the forecast is for an unusually hot and humid day, it would be advisable to let the unit run on a continuous basis because it will consume less energy in holding the load than it would in trying to pull down the load on startup again.

Central HVAC Plant Operations

General

Shut down unitary air conditioning equipment when buildings are unoccupied to achieve substantial energy savings. Examine energy use in buildings served exclusively by the central HVAC system, and determine what has to be done to permit the maximum shutdown of energy consuming equipment, during periods when buildings have few or no occupants on weekdays, after 17:00, during weekends and on holidays.

Boiler Operations

Operate boilers at design pressure and temperature, exercising due caution to ensure that undue thermal stresses are not created in non-cast iron boilers. Consider eliminating hot standby boilers since, in many cases, a boiler failure will not cause serious hardship. Examine operating procedures when more than one boiler is normally in use. (It is far more efficient to operate one boiler at 90 percent capacity than two at 45 percent capacity.)

Periodic Boiler Tune-up

Carry out periodic boiler tune-up by:

a) Checking flue gas analysis frequently. The efficient combustion of fuel in a boiler requires burner adjustments to achieve proper stack temperature, CO_2 level, and excess air settings. Check settings to provide stack temperatures of no more than 83°C above steam or water temperature. There should be no carbon monoxide. For a gas fired unit, CO_2 should be present at 9.5 to 9.8 percent; for no. 2 oil, 10.5 to 12.0 percent; for no. 6 oil, 12 to 13.5 percent;

b) Adjusting air/fuel ratios of firing equipment. If there is insufficient air, the fire will smoke, causing tubes to become covered with soot and carbon, lowering their heat transfer efficiency. If too much air is used, unused air is heated by combustion and exhausted up the stack, wasting energy.

Chiller Operations

Operate one of multiple compressors and/or chillers at full load, rather than two or more at partial load. Operate condenser

water systems at lower temperatures, and operate only chilled water pumps and cooling tower fans when necessary. Elevate chilled water temperatures when humidity conditions permit.

NOTE: Refer to Public Works Canada, Energy Conservation (E.C. Series) publications for guidance in achieving effective and efficient plant operations. Although some of the above operating criteria are described for central plant operations, they apply as well to heating and cooling plants serving individual buildings.

Food Service Operations

General

Conserve hot water and/or steam in food service operations whenever possible. Operate electrical or gas heating equipment for the minimum required time. Consider installing timers to turn on heating equipment prior to regular operating hours for items requiring preheating.

Refrigeration Equipment

Ensure that doors on walk-in freezers are open for a minimum of time only when access is required. Check door gaskets periodically and replace ones that leak air. Defrost refrigerator units on a regular basis so that ice does not build up on cooling coils. Clean condenser coils at least once per month to prevent dirt build up.

Client Operations

General

Encourage building occupants to wear warmer clothing in the winter months, and cooler apparel during the summer months. Request occupants to refrain from complaining if they experience slight discomfort due to temperatures in the building which exceed the guidelines for brief periods of time during normal working hours. Request building occupants to refrain from opening windows in air conditioned buildings.

Use of Draperies and Venetian Blinds

Where draperies and/or venetian blinds are provided, close them at night and on sunless days during the heating season, to reduce heat loss to the exterior. During the cooling season, request building occupants to close venetian blinds and drapes on hot sunny days to reduce the cooling load.

Heating and Cooling Supply Outlets

Request building occupants to ensure that perimeter fan coil unit grills, radiators and other supply outlets are kept clear of papers, books and other obstructions which could impede the flow of conditioned air into the room or area.

2- Ventilation and Exhaust Systems

Operating Criteria

PWC operating guidelines require that except for purposes of cooling with outside air, ventilation rates shall be maintained in accordance with PWC Standards of Guidelines No. MD15000, 'Environment'

a) Working hours - 500 mL per second/m^2 (0.1 CFM/square foot)

b) Silent hours - none

To satisfy the above criteria, operating adjustments and other measures described in the following paragraphs should be carried out in all PWC buildings, to the extent practicable.

Operation of Building Ventilation and Exhaust Systems

General

Set ventilation rates at 500ML per second/m^2 (0.1 CFM/square foot) maximum between 08:00 and 17:00 weekdays. Consider closing outdoor air dampers during the first and last hour of occupancy, i.e. from 07:00 to 08:00, and from 16:00 to 17:00 weekdays and during weekends and holidays, when air must be heated or cooled, except when operating on economizer cycle during the summer months. Consider installing controls to shut down the building ventilation system automatically for those periods when the building is unoccupied. Reduce exhaust air quantities to the extent possible, and reduce outdoor air to the minimum required to balance the exhaust requirements and maintain a slight positive pressure to retard infiltration-caused heat losses and heat gains. Provide a wind break or install baffles to prevent wind from blowing directly into an outdoor air intake.

Laboratory and Food Service Operations

Use exhaust hoods in laboratories and food service areas only when operations are underway. Consider adding control dampers or gravity dampers to keep the air path in the exhaust duct closed when the fan is not operating. Operate exhaust systems for the minimum required time only.

Parking Garage Operations

Consider the installation of a CO monitoring and control system for the garage ventilation system(s).

Building Washrooms

Consider shutting off direct outdoor air supply to washrooms and other potentially odourous areas. Permit air from other areas to migrate into such areas through door grills and be exhausted. Alternatively, reduce the volume of washroom exhausts in buildings which have multiple washroom exhaust fans having a total fan capacity in excess of outside air requirements. This can be done by wiring a fan interlock into washroom lights through a timed relay, so that the fan is activated only when lights are on. An administrative notice to the effect that lights should be turned off when the room is not in use will help ensure that lights (and the fan) are off when the room is not being used. Another method involves dampening down air volume so that only that amount of air required by the code is removed.

3- Building Lighting Systems

Operating Criteria

PWC operating guidelines require that lighting in PWC administered buildings be maintained in accordance with the following criteria:

a) Interior lighting (occupied space)
   - 550 to 800 Lux (50 to 75 footcandles) at work stations;
   - 300 to 500 Lux (30 to 50 footcandles) in work areas;
   - 100 Lux (10 footcandles) in non-work areas.

b) Interior lighting (unoccupied space)
   - none except that required for safety and security.

c) Exterior Lighting
   - none except that required for safety and security

d) Decorative lighting
   - as approved by PWC Headquarters for individual buildings.

To satisfy the above criteria and also realize the maximum energy saving possible in the operation of building lighting systems, operational adjustments, system adjustments, and other measures described in the following paragraphs should be carried out in all PWC buildings, to the extent practicable. Because the lighting systems of many existing buildings were designed within the restrictions of initial cost economies, without knowledge of final space use and sub-division, there exists significant potential for lighting system modification, including delamping. These modifications can reduce substantially the energy consumed by the lighting system while still providing building occupants with the quality and quantity of illumination required to perform their various tasks and functions.

However, before undertaking any change, it must be recognized that a lighting system has many elements, all interrelated with one another, and that the lighting system itself is interrelated with other systems in the building. While energy can be saved by properly removing lamps and luminaires, disconnection of ballasts, etc., to satisfy PWC operating criteria, such action should only be taken after the entire system has been analyzed and all options evaluated. While energy conservation through delamping is important, it must be achieved in a manner consistent with other requirements, including those of productivity and visual comfort, aesthetics, affect on working conditions subject to consultation under existing employee group contracts, federal, provincial and municipal codes and ordinances, etc. It is also important to recognize that major alterations to a lighting system can have a significant impact on heating and cooling systems, most of which were designed to consider the amount of heat given off by the lighting system as originally designed.

For the above reasons, it is strongly recommended that competent professional assistance be obtained before any significant modifications are made to interior building lighting systems. Such modifications might include delamping to achieve lighting levels specified in the operating guidelines, or adjustments to light switching arrangements to facilitate turning off the maximum amount of building lighting, when cleaning operations are underway, but the building is otherwise essentially unoccupied. Property Managers should ensure that projects involving delamping or modifications to light switching arrangements are accorded the highest priority.

Operation of Building Lighting Systems

General

In consultation with client authorities and regional PWC staff, develop plans for the reduction in lighting levels in the building to achieve the operating criteria described above. Establish an effective lighting use program - a planned program to turn lights on only when and where they are needed, and to turn lights off when space is unoccupied, even for brief periods of time. Such programs can be tailored to the individual characteristics of the space and needs of its occupants. Modifications to light switching arrangements may be required, and these should be planned and carried out as quickly as possible.

Light Switching Arrangements

Establish a program to modify light switching arrangements, if necessary. Consider the need for more switching near work stations, and separate switching for banks of perimeter light fixtures. Consider posting a small sign or chart near each light switch to identify which lights are controlled by the switch, so that occupants can be more selective and encouraged to turn off lights observed to be on, but not in use, outside of their working area. Such postings will help to reduce trial-and-error which can consume significant amounts of energy as banks of lights are quickly activated and deactivated. Discourage night security staff from turning on all lights each morning in advance of employees arriving for work.

Building Outdoor Lighting Systems

Reduce outdoor security and safety lighting to the minimum required. Coordinate street lighting with security lighting and eliminate duplication. Use photo cells for turning on exterior lights and time clocks for turning off exterior lights. Turn off all decorative floodlighting and display lighting not specifically approved for continued use.

Cleaning Schedules and Cleaning Operations

Consult with the building cleaning contractor, or the PWC component of the PSAC Local for buildings cleaned with PWC staff, to have the cleaning operations rescheduled, as follows:

a) Routine Cleaning
Routine cleaning operations should be performed Monday through Friday, utilizing one of the following options, in the following order of preference from an energy conservation standpoint:

- During daylight hours.
- During daylight hours with exception of wastebaskets and ashtrays which will be emptied and cleaned between 17:00 to 19:00.
- Commence at 17:00 and conclude at 21:00.
- Commence at 19:00 and conclude at 23:00 to avoid peak demand period.

Cleaning operations should be carried out in such a manner that no more than 25 percent of the building will be illuminated while cleaning operations are underway during unoccupied hours, i.e., work should be completed on each floor, or section of a floor, and lights switched off in that area, before proceeding to the next floor or section of a floor to commence operations in that area. Where individual offices are equipped with light switches, lights are to be turned on when entering to clean the office, and switched off, immediately, on leaving the office to proceed to clean the next office.

b) Scheduled Operations
Scheduled operations will be performed on Saturdays and Sundays between the hours of 08:00 to 16:00. Alternatively, scheduled operations will be performed Monday through Friday between the hours of 11:00 to 07:00. The contractor or cleaning services foreman is to ensure that only lighting in the immediate area of operations is used, and that lights are switched off in the area, before the crew commences operations in another area of the building.

Cleaning Services Specifications and Contracts

Where the above schedules cannot be established at reasonable cost by amending the existing contracts, ensure that these requirements are included in the new specification before tenders are called for a new contract. At time of award, require the contractor to submit in writing, his plan of operation to conform with the above requirements.

Maintenance of Building Lighting Systems

Maintaining Illumination Levels

The maintenance of lighting equipment to ensure adequate illumination levels takes on added significance with non-uniform lighting and lower lighting levels that will exist after delamping. Periodic inspection will be required to ensure that task lighting levels do not fall below 70 percent of nominal specified design levels. These inspections should also be used to confirm that if tasks have been relocated, adequate lighting has been provided at the new location, and excess lighting has been removed from the old location. Measures to be taken to ensure maximum lighting efficiency are as follows:

a) wipe lamps clean at regular intervals;
b) clean reflecting surfaces and shielding media frequently. Replace lens shielding that has yellowed, or become hazy, with clean acrylic lens with good non-yellowing properties;
c) clean ceiling, walls and floors frequently to improve reflective qualities;
d) where light output has fallen below 70 percent, relamp all fixtures in the group at the same time. This will also be an opportunity to determine whether a more efficient, lower wattage, lamp would be suitable.

Client Operations

General

Building occupants should be trained and assigned responsibilities for the efficient utilization of lighting with established schedules for control of lighting. Campaign for better lighting utilization by using letters, memos, signage and personal contacts to encourage building occupants to use lighting only when it is needed, to use only the amount of lighting required, and to turn off lights whenever they are not needed. Encourage building occupants to switch off lighting in locations close to windows, when there is sufficient daylight to perform tasks not requiring high illumination levels, when this can be done without physical discomfort being experienced by individuals in the area.

Building Occupants Required to Work in a Building after Normal Working Hours

When existing circuitry makes it impossible to utilize less than 25 percent of the lighting in a large area, when light is needed, and individual employees are required to work in the building after normal working hours, consider intiating a desk lamp issue program which would enable employees, working at night, to use a

single desk lamp or two, instead of turning on a large bank of luminaires. Alternatively, consider requiring employees to take their working materials to a small working room in the interior core of the building, where lighting use can be restricted to the confines of that room, and where all employees working in the building after normal working hours, can be accommodated.

NOTE: Refer to PWC publication "Guidelines for Lighting Energy Conservation in Government Offices", (EC 201) Nov., 1977 for guidance on delamping, and lighting energy utilization.

4- Domestic Hot Water Systems

Operating Criteria

PWC operating guidelines require that domestic hot water temperatures in PWC administered buildings be reduced and maintained at a maximum of 38°C only, when the building is occupied.

Operating Adjustment and Control

To satisfy the criteria described above, the following measures should be carried out:

a) Inspect and test hot water cotrols to determine if they are working properly. If not, either regulate, repair or replace them.

b) Add thermostats to domestic water circulating pumps to maintain water at 38°C in the circulating loop.

c) Add controls to domestic water circulating pumps and/or domestic water heaters to shut them down during unoccupied building hours.

d) If water pressure exceeds 40 to 50 pounds, consider installing a pressure-reducing valve on the main service to restrict the amount of hot water that flows from taps.

e) Boost hot water temperature locally for kitchens and other areas where required, rather than providing higher than necessary hot water temperatures for the entire building.

Refrigerated Water Fountains

Set the thermostats so that the drinking water temperature shall be not less than 18°C during the summer months.

If the water temperature is below 18°C during the other seasons, then shut off the refrigeration systems during that time.

5- Car Engine Block Heater Outlets

Operating Criteria

Policy governing the installation of car engine block heater outlets is contained in Treasury Board Minute number 551601, Treasury Board Circular 1960-11. An article is currently being prepared for promulgation in the Property Administration Branch Manual requiring that:

a) All unauthorized car block heater outlets be discontinued and removed;

b) authorized outlets be used only for authorized vehicles; and

c) that outlets are not to be used to supply power to car warmers, battery heaters, seat warmers, battery chargers, etc.

Installation of Timers

The article proposes that with the exception of outlets provided for vehicles having indeterminate duration parking requirements, i.e., some service and inspection vehicles, all car engine block heater outlets should be controlled by a timing device so that the outlet is energized only approximately two hours before the vehicle is required to be operated. The energization period should be planned to avoid coinciding with peak power demand periods, to the extent possible.

CHECK LIST

1 a) Building ______ d) Gross Area ______ m^2

b) Address ______ e) Inspector ______

c) Cost Centre ______ f) Date of Inspection ______

2 Facility Record

a) Clients
- i) Federal ______
- ii) Commercial ______
- iii) Others ______

b) Inside Parking
- i) Heated ______
- ii) Un-Heated ______

c) Warehouse/Storage
- i) Heated ______
- ii) Un-Heated ______

d) Canteen ______

e) Cafeteria ______

f) Parking Outside ______
- i) Plug-Ins ______

g) Heating Facilities
- i) C.H.P. ______
- ii) Boiler Room ______
- iii) Furnace ______
- iv) Electric ______

h) Air Conditioning
- i) C.H.P. Ch.W. Supply ______
- ii) Central System ______
- iii) Unitary System ______
- iv) Other ______

i) Special Areas ______

3 Categories of Space (see note)	Total Area	(Inside Gross Area) Area in which Guidelines Planned or Implemented (m^2)
a) Office ______	1 ______	2 ______
b) Commercial ______	1 ______	2 ______
c) Process ______	1 ______	2 ______
d) Warehouse ______	1 ______	2 ______
e) Inside Parking ______	1 ______	2 ______
f) Housing ______	1 ______	2 ______
g) Special ______	1 ______	2 ______
h) Educational ______	1 ______	2 ______
i) Service Area ______	1 ______	2 ______

4 Hours when building is occupied ______

5 Client Departments (List) ______

6 Other Tenants (List) ______

7 Building Services

a) Canteen Cafeteria ______	In-House ______	Contract ______
b) Cleaning ______	In-House ______	Contract ______
c) Horticulture ______	In-House ______	Contract ______

	Inspected (Date)	Deficiency Recorded (Date)	Operations Adjusted (Date)	Retrofit Completed (Date)	Remarks
8 Operational Guidelines					
a) Heating Systems					
i) Temperature Control Settings					
ii) Air Systems					
iii) Commercial Areas					
iv) In-Door Garages, Loading Docks					
v) Lobbies, Corridors and Vestibules					
vi) Portable Electric Heaters					
vii) Ramp Snow Melting Systems					
viii) Roof Melting Systems					
ix) Storage Rooms					
x) Humidification Systems					

CHECK LIST

	Inspected (Date)	Deficiency Recorded (Date)	Operations Adjusted (Date)	Retrofit Completed (Date)	Remarks
b) Cooling Systems					
i) Temperature Control Settings					
ii) Outside Air Dampers					
iii) Storage Spaces					
iv) Reheat Adjustments					
v) Window and Through-Wall Units					
c) HVAC Plant Operations					
i) Equipment Operating Times vs Loads					
ii) Boiler Operations					
iii) Flue Gas Analysis					
iv) Air/Fuel Analysis					
v) Chiller Operations					
d) Food Service Operation					
i) General					
ii) Refrigeration Equipment					
e) Client Operation					
i) Provide Guidelines to Client Administrative Staff(s)					
f) Ventilation and Exhaust Systems					
i) Control Settings					
ii) Laboratories and Food Services					
iii) Parking Garage Operations					
iv) Washrooms					
g) Lighting Systems (See EC 201)					
i) Operational Criteria					
ii) Operational Program					
iii) Switching Arrangements					
iv) Outdoor Lighting					
v) Lighting Levels					
h) Cleaning Operations					
i) Cleaning Operations					
i) Domestic Hot Water Systems					
i) Operating Criteria					
ii) Ancillary Equipment					
j) Car Engine Block Heaters					
i) Operating Criteria					

MISCELLANEOUS REMARKS

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Inspector ____________________ Date ____________________